VALLES MARINERIS, MARS: VOLATILES IN INTERIOR DEPOSITS? B. K. Lucchitta and C. E. Rosanova, U.S. Geological Survey, Flagstaff, Arizona 86001.

A GIS (Geographic Information System) approach has shed light on three-dimensional relations of geologic units in the central Valles Marineris. Black-and-white and color images and digitized topography were superposed. The images were then placed into oblique perspective views to highlight critical relations. The images showed that extensive mass wasting may have occurred on interior layered deposits in west Candor Chasma and that some mass wasting occurred in Ophir and central Candor Chasmata. The configuration of the mass wasting features suggests that volatiles were involved. Most likely, the volatiles were derived from former lakes in which older interior deposits were laid down during early stages of the development of the Valles Marineris.

The central Valles Marineris are particularly well suited to studies in three dimensions, because their nearly 10-km depth permits vertical exposures. For west Candor Chasma, we produced animage mosaic of 12 high-resolution black-and-white Viking Orbiter images of revolutions A915 and 919 (red filter) and A065 and 066 (clear filter), resolutions about 60 to 80 m/pixel. We merged the images with the Viking global color mosaic (resolution about 1 km/pixel) and digitized topography of Coprates Chasma Northwest, scale 1:2,000,000 [1], contour interval 1 km. For central Candor Chasma, we merged about 40 Viking Orbiter images, revolutions 913A to 917A (red filter), resolutions about 60 m/pixel, with color images of revolution 586A and a digitized topographic map of 200-m contour interval. We also pasted in a strip of very high resolution images of Viking Orbiter revolution A815 (resolution 20 to 30 m/pixel). We then created oblique views of pertinent features using the "Surveyor" software developed by the Jet Propulsion Laboratory. As the topography is much less precise than the images, misregistrations are evident in places. In spite of this shortcoming, critical relations can be observed that are very helpful in geologic interpretations.

Westernmost Candor Chasma contains a central high mesa of light-colored layered deposits. The oblique images show that the layered deposits are tilted in places. The high mesa is surrounded by irregular deposits of medium to high albedo. Locally this material merges with the layered deposits as if they were the same unit. Other material forms fan-like, lobate deposits on the mesa flanks. A light-colored lobe emerges from the top of the mesa. The flanks of another stack of interior deposits, located southeast of the above-discussed mesa, is completely covered by small, lightcolored lobes, giving the stack the appearance of a melting ice cream cone. Some of the lobes flowing from the layered mesas bury landslides and are therefore younger than the slides. The configuration and color of the various fan-shaped and flow-lobe deposits suggest that the materials are young mass-wasting products. The alternative interpretation, volcanic deposits, is less likely because of the generally light color of the flow-lobe materials and the merging of layered deposits with irregular deposits. If caused by mass wasting, the length and shape of some of the lobes suggest that volatiles were involved in emplacing the flows. The observations can be explained if the older interior deposits collapsed, flowed out, and some became transformed into the younger units. The observations thus support the idea that layered deposits in the mesas had incorporated water or ice when they were deposited in lakes.

Evidence from Ophir and central Candor Chasmata also support that interior deposits collapsed; they locally show tilted beds and break-away scarps. The tilted beds are most noticeable in upper layers that overlie a lower, massive unit that is similar to wall rock in color and albedo [2,3]. The tilting could be of tectonic origin, but the break-away scars suggest mass wasting instead. Thus, the relations seen in the images are consistent with an interpretation that upper layers collapsed locally after the lower massive unit was removed by flow or evaporation. The bedding, uniformity of outcrop, color, and albedo support the proposition of Lucchitta et al. [4] that the lower massive unit is composed of mass-wasted wall rock deposited in ancestral, incipient Valles Marineris troughs that were disconnected and may have harbored lakes. Thus the lower massive unit may have become charged with volatiles, setting the stage for later collapse.

To prevent loss of volatiles incorporated in old sediments in troughs, it is required that the sediments were shielded from the atmosphere. They may have been buried. Evidence exists that burial may indeed have taken place; varied and thinner bedded layers overlie the older massive deposits [5,6,3]. The appearance of these younger deposits is compatible with an interpretation as volcanic rocks [7]. Also, to prevent early collapse of volatile-rich sediments, they must have been confined. Relations in east Candor Chasma suggest that the ancestral troughs may once have been completely filled with sediments [4]; the ancestral trough walls thus would have provided the confining barriers.

The shape of the ancestral troughs eventually changed; now the troughs are larger and contain free-standing mesas. Tectonic activity and volcanism may have caused the change: newly formed grabens appear to have enlarged the ancestral troughs and created new voids, leaving the interior deposits as benches and mesas [4]. Lateral support may thus have been removed from the layered deposits, inducing the lower ice-rich layers to flow and causing the upper, possibly volcanic, layers to collapse. Evaporation of the liberated volatiles may have added to the voids. Post-graben volcanic activity apparently also occurred and may have provided heat flow to induce further melting of ice and disintegration of interior deposits. Evidence for relatively recent volcanic activity is particularly prevalent in westernmost Candor Chasma, where the most conspicuous mass wasting on interior deposits apparently occurred. There, very dark material crops out at the base of surrounding trough walls and at the base of the interior mesas. Locally the dark material has radiating rays. This dark material overlies all other deposits and has been identified as mafic in composition [2,7]. Anomalous color in one of the mesas has been attributed to possible hydrothermal activity [8,3].

The discovery of mass wasting on interior layered deposits is new; the observation is counter to generally accepted hypotheses that consider the interior layered deposits to be composed of stable, competent material [6]. The discovery of such mass wasting supports an interpretation of the lower interior deposits as composed of volatile-rich sediments and a previous proposition that the troughs underwent a two-stage history. Accordingly, ancestral troughs may have harbored lakes into which wall rock was shed; later tectonic enlargement created the present configuration.

REFERENCES: [1] U.S. Geological Survey (1986) U.S. Geol. Surv. Misc. Invest. Ser. Map, I-1712. [2] Geissler, P.E., Singer, R.B., and Lucchitta, B.K. (1990) JGR, 95, 14399-14413. [3] Komatsu, G., Geissler, P.E., Strom, R.G., and Singer, R.B. (1993) JGR, 98, 11105-11121. [4] Lucchitta, B.K., Isbell, N.K., and Howington-Kraus, A. (1994) JGR, 99, 3783-3798. [5] Nedell, S.S., Squyres, S.W., and Anderson, D.W. (1987) Icarus, 70, 409-441. [6] Lucchitta, B.K., McEwen, A.S., Clow, G.D., Geissler, P.E., Singer, R.B., Schultz, R.A., and Squyres, S.W. (1992) in Mars, University of Arizona Press, 453-492. [7] Lucchitta, B.K. (1990) Icarus, 86, 476-509. [8] Geissler, P.E., Singer, R.B., Komatsu, G., Murchie, S., and Mustard, J. (1993) Icarus, 106, 380-391.